HYCOM Data Service and Web Outreach

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http://www.hycom.org

LONG-TERM GOALS

The goal of this project is to develop and implement a comprehensive data management and distribution strategy that allows easy and efficient access to HYCOM-based ocean prediction system outputs to (a) coastal and regional modeling sites, (b) to the wider oceanographic and scientific community including climate and ecosystem researchers, and (c) the general public especially students in middle and high schools.

OBJECTIVES

To develop and implement a data sharing system using existing open source software packages to distribute HYCOM-based ocean prediction system data via the Internet.

APPROACH

The basic idea is to setup web services that enable access to backend data management, distribution and visualization applications. These applications enable end users to obtain a broad range of services such as browsing of datasets, gif images, downloading NetCDF files, FTP request of data etc. The HYCOM Data Sharing System is built upon three existing software components: the Open Project for Network Data Access Protocol (OPeNDAP) Servers, Unidata's Thematic Realtime Environmental Distributed Data Services **(**THREDDS) server, and the Live Access Server (LAS). These tools and their use to distribute the data are described below.

a) OPeNDAP

OPeNDAP (http://www.opendap.org) is the middleware that provides uniform binary-level access to scientific data on the Internet. There are three components to OPeNDAP: servers, client libraries, and a format-neutral data transport protocol. The protocol may be thought of as XML-tagged data descriptions (metadata) with associated non-parsed (binary data) content. OPeNDAP servers provide access to existing formatted files (e.g., netCDF, HDF etc.) through the OPeNDAP Data Access Protocol. Servers are typically available as binary executables that the data provider can quickly install. Existing and new client applications are supported through the OPeNDAP client libraries. Support for clients that utilize netCDF is particularly simple, as the netCDF native libraries have been OPeNDAP-enabled so that a simple relinking of an application is often sufficient to OPeNDAP-enable it (see Figure 1).

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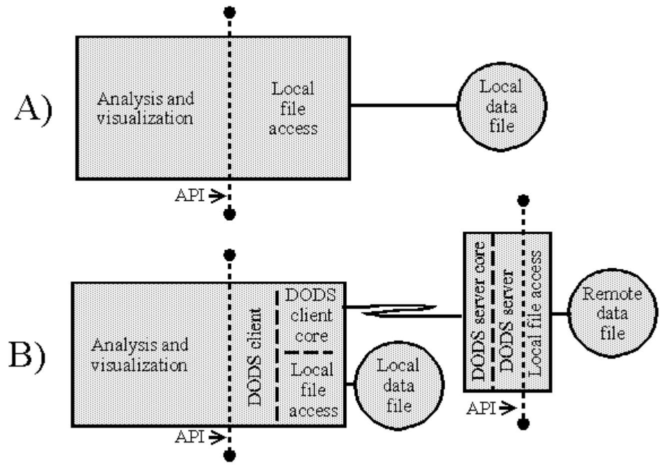

Figure 1. Adding OPeNDAP capabilities to an existing application. Figure A illustrates the Application Programmer Interface (API) as the boundary across which a scientific application makes requests to its local file access libraries (e.g., netCDF) to read and write data files. Figure B illustrates the same scientific application relinked with OPeNDAP. The OPeNDAP client mimics the API used for local file access, directing the requests to the local file access libraries, or to the network as appropriate.

The OPeNDAP group has also developed a HYCOM specific data access GUI tool for use with MATLAB (see Figure 2 below). It is available form www.opendap.org .

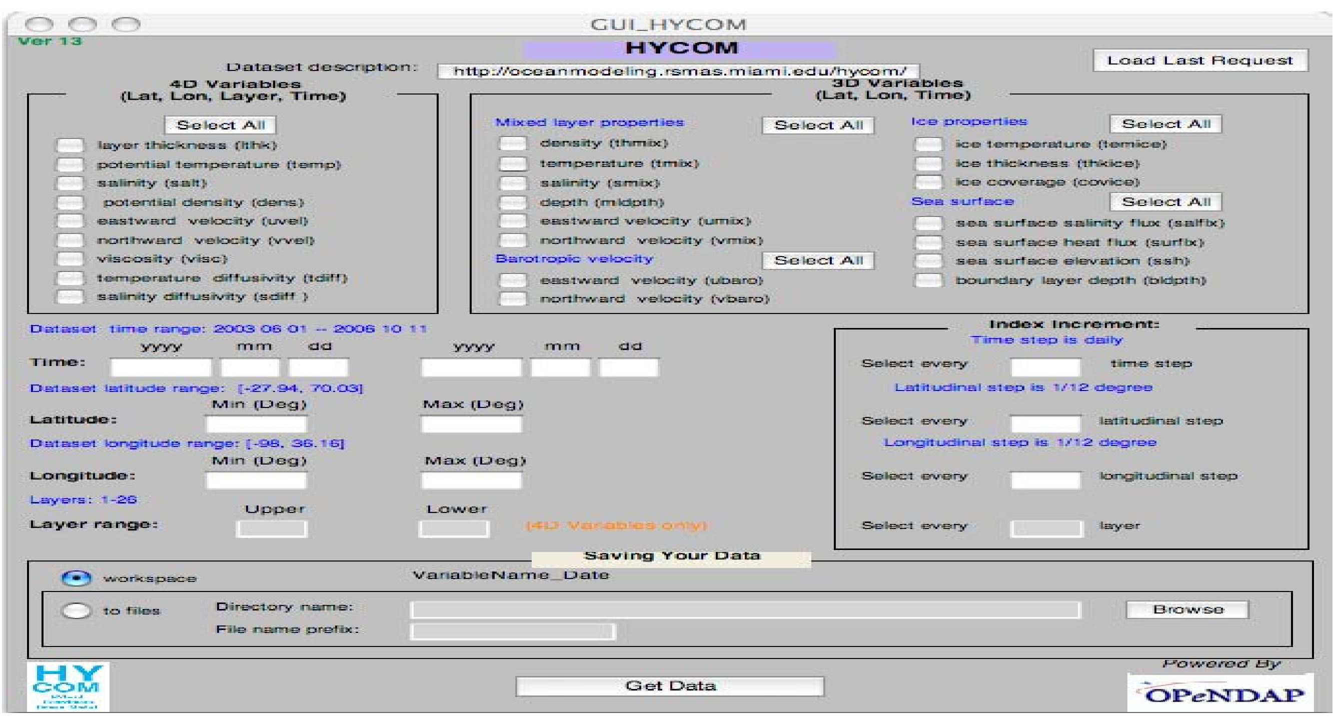

Figure 2. Screen shot of the MATLAB GUI OPeNDAP client developed for HYCOM data access.

b) THREDDS Data Server

The THREDDS Data Server (TDS) is a web server that provides cataloging service, metadata and data access for scientific datasets. It consists of an integrated server that provides OPeNDAP access to any dataset stored in a format compatible with the Common Data Format such as NetCDF etc. The server also provides bulk file access through the HTTP protocol and data access through the OpenGIS Consortium (OGC) Web Coverage Service (WCS) protocol for any "gridded" dataset whose coordinate system information is complete. It also allows netcdf files to be aggregated to allow access to data stored in multiple files as a single logical file. The HYCOM THREDDS catalog is accessible at http://hycom.coaps.fsu.edu/thredds/dodsC/ and is shown below.

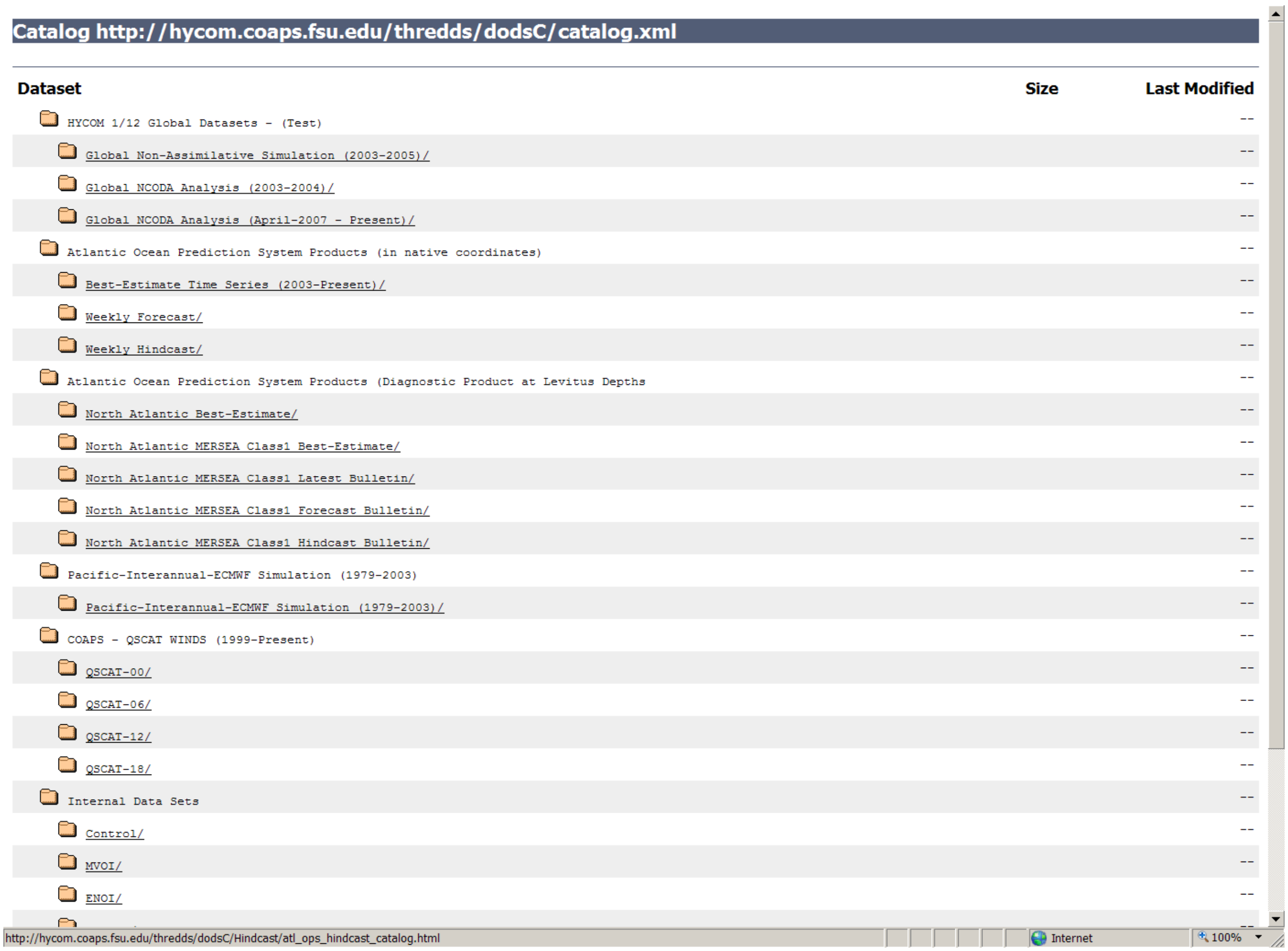

Figure 3. Screenshot of the HYCOM THREDDS catalog listing the available datasets.

c) LAS

The LAS (http://www.ferret.noaa.gov/LAS/) is a configurable scientific data "product" server (see Figure 2). It provides a friendly user interface to ocean/atmosphere/climate data browsing, download, and comparison on the Web. A user can quickly obtain products such as plots, images, and formatted files generated on-the-fly from custom subsets of variables.

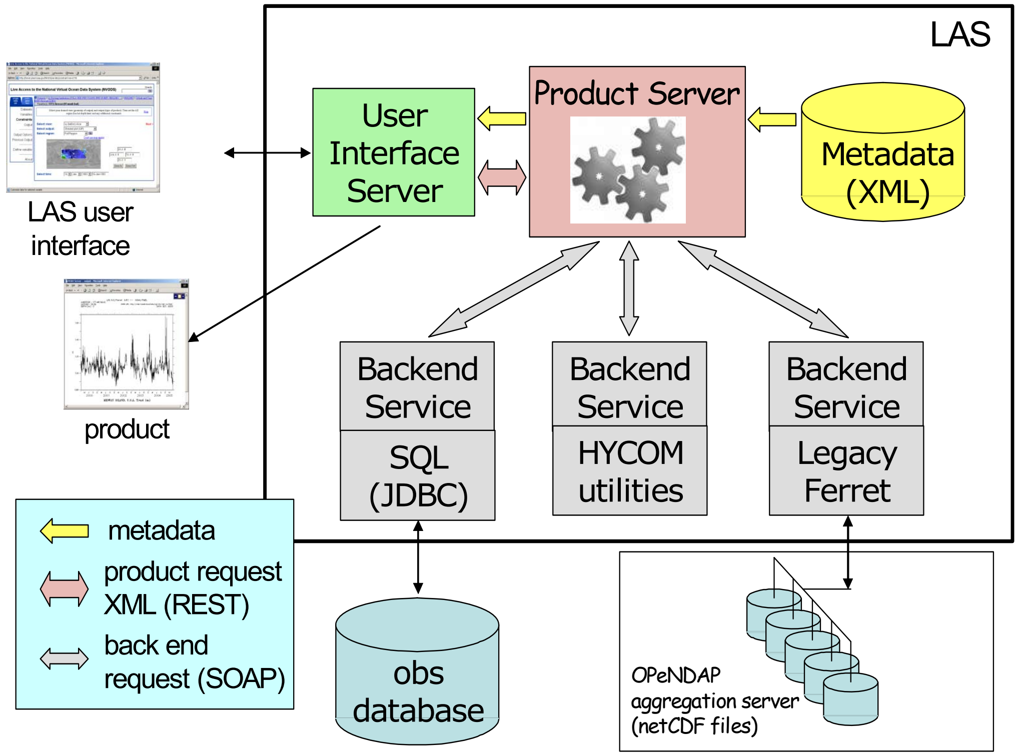

Figure 4. The heart of LAS is a "product server"

During FY07 major enhancements have been made to LAS in support of HYCOM modeling. These include the LAS "Slide Sorter"; animations; outputs to Google Earth; GIS compatibility; and improvements to the LAS code framework. These will be discussed separately, below:

i) Slide_Sorter

Model intercomparison, and indeed analysis of single models, is challenging in part because the number of fields that need be examined is so large. The LAS Slide Sorter is a specialized interface to assist HYCOM scientists with this challenge. If we think of a HYCOM model ensemble as occupying a 5-dimensional space (3-space, time, ensemble axis), then a 2D contour plot leaves three axes to navigate. The Slide Sorter allows the user to choose one of these axes as the axis of comparison and then to quickly select positions along the other two axes through menus. Due to recent performance enhancements (see below) LAS system response remains quick, even when generating the multiple visualizations required in the Slide Sorter.

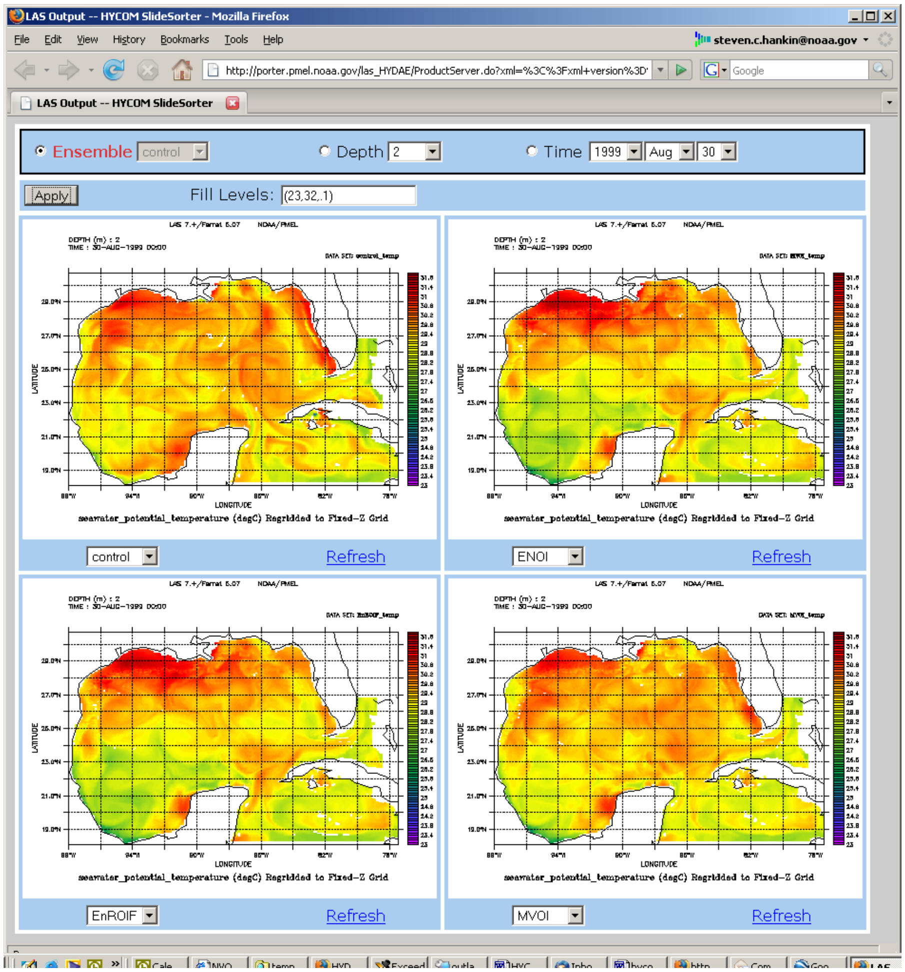

Figure 5. LAS Slide Sorter output showing the HYDAE model intercomparison

ii) Animations

A generalized animation capability has been added to LAS, essentially making it possible to view on-the-fly animation sequences of any visualization that the system offers. This gives the user full control over space-time domain, variables, contour levels, color palettes, and other graphical layout options when generating animations. Animations may be generated for maps, zonal and meridional sections and even line plots.

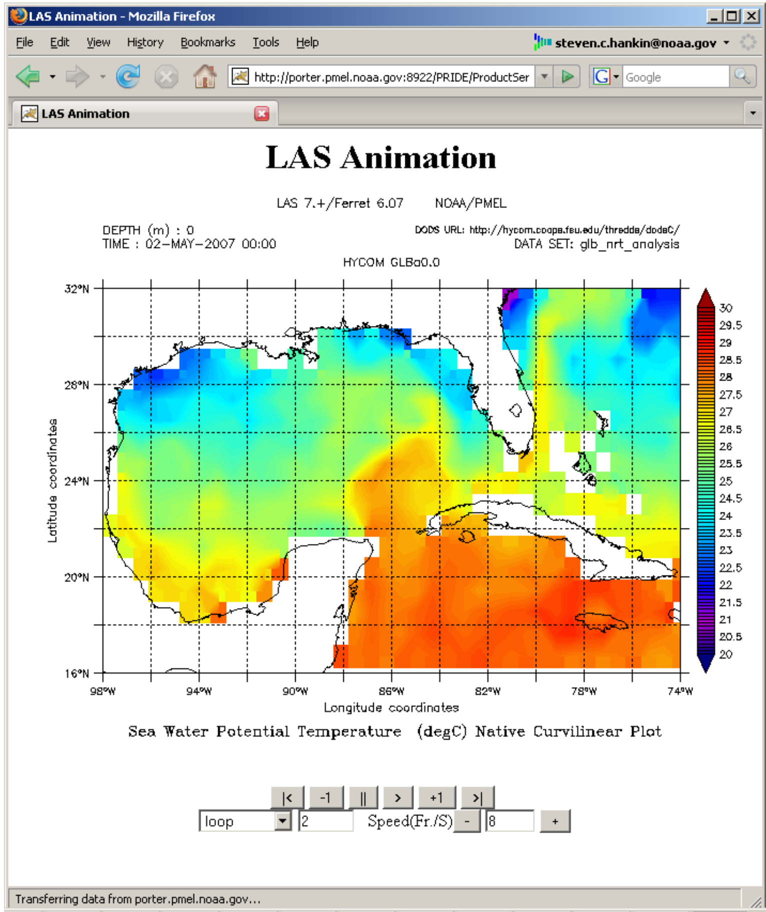

Figure 6. LAS Animation from the Global operational outputs

iii) Outputs-to-Google-Earth®

Through visualization on Google Earth® HYCOM global model outputs can be made accessible in classroom settings and to other general audiences. It also provides a quick reference for casual discussion among scientists. To address the high resolution (high data volume) of HYCOM 1/12 degree global outputs LAS has implemented a sophisticated interface to Google Earth. Based upon the current zoom level at which the Google Earth user is examining the HYCOM fields LAS automatically decimates ("strides") the data that it accesses. The result is that as the user zooms in the apparent resolution of the data continually increases, while always maintaining satisfactory performance.

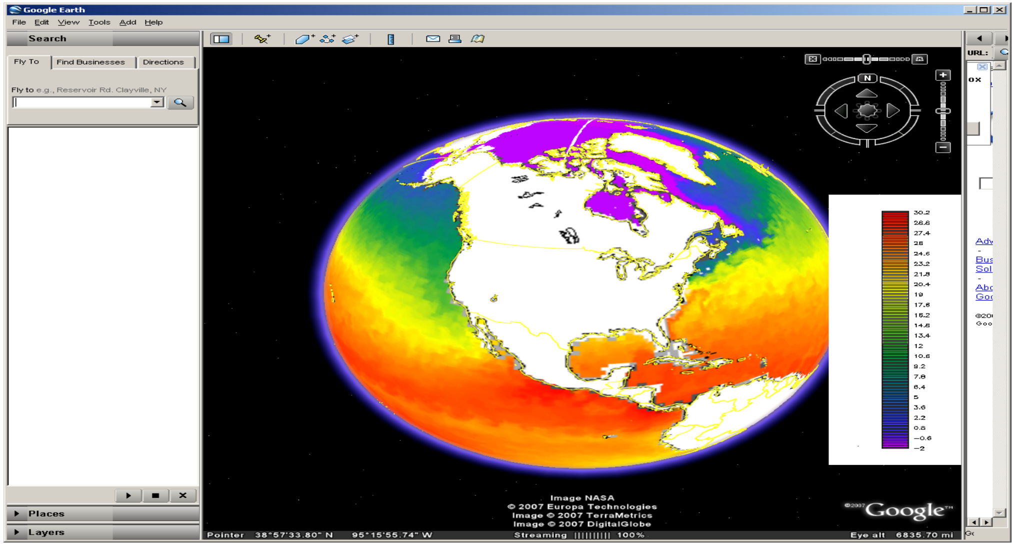

Figure 7. LAS output mapped to Google Earth®

iv) GIS-compatibility

Like outputs to Google Earth the ability to output to the emerging open standards of the GIS community is an important outreach tool for the HYCOM consortium. LAS has added a beta-level capability to output to two of the most common standards that are being advanced by the Open Geospatial Consortium (OGC). These are the Web Mapping Service (WMS), which makes images (maps) of HYCOM outputs available, and the Web Coverage Service (WCS), which makes binary grids of data available.

v) Improvements to the LAS code framework

A great number of improvements have been made to the code framework that supports HYCOM model dissemination through LAS. Key among these are automated decimation (striding), to provide high performance access to high resolution fields, when viewed over broad areas where the full resolution of the data is excessive; server-side analysis through OPeNDAP, which was introduced by building upon the Unidata THREDDS Data Server (TDS -- http://www.unidata.ucar.edu/projects/THREDDS/); and new tools to create compatibility between curvilinear and rectilinear grid representations of HYCOM outputs.

c) HARDWARE

Since January 2007, the HYCOM data service is hosted on state-of-the-art hardware consisting of a Storage Area Network (SAN) that links 6 RAID arrays providing 100 TB of total storage to three servers each with 8 CPUS and 32 GB of memory via a high speed Fibre Channel network. A global file system which provides a single system image is also installed in the servers. The high CPU count and large memory machines are very useful for multi-threaded large data serving applications operating on large datasets.

RESULTS

The Hybrid Coordinate Ocean Model (HYCOM) consortium’s data service provides access to datasets listed below.

- 1/12° global near-real-time ocean prediction system outputs (updated daily)
- 1/12° global HYCOM+NCODA hindcast dataset 2004-2006
- 1/12° global HYCOM non-assimilative simulations 2003-2006
- 1/12° Atlantic Ocean Prediction Outputs
- 1/12° Pacific Inter-annual simulation outputs 1979-2003
- 1/3° North Atlantic Simulation 1950-2004 (not public; used internally)

The total size of the datasets is about 70 TB. These datasets are accessible from http://www.hycom.org/dataserver and links within (see screenshot below).

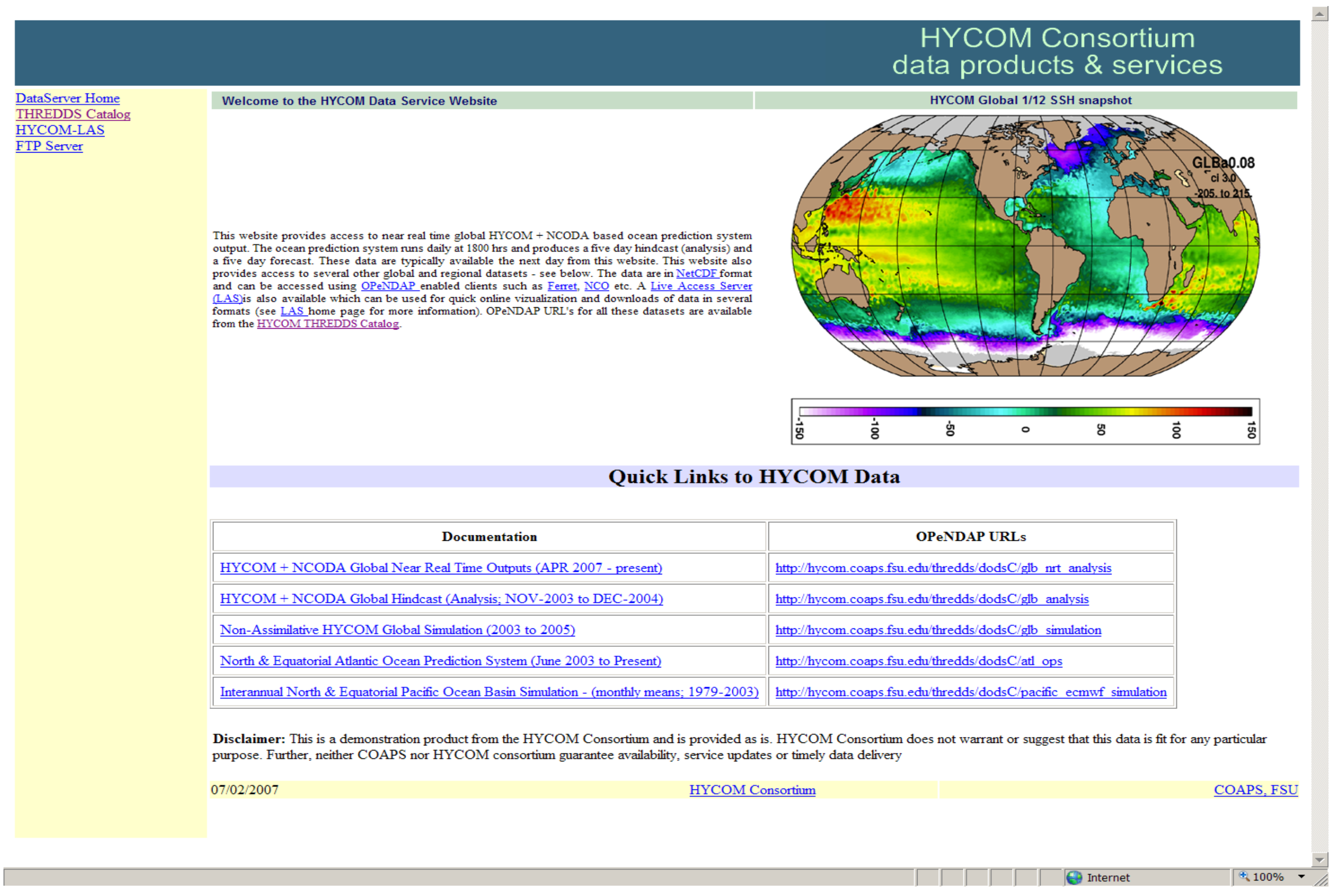

Figure 8. Screenshot of the HYCOM data service website listing quick links data.

IMPACT/APPLICATIONS

This system provides easy and efficient availability of ocean model data to satisfy ocean data needs of researchers and operational modeling sites.

TRANSITIONS

a) Online model output used as input for coastal ocean models
b) Online model output used as input for biochemical studies
c) Online ocean prediction system output used in adaptive sampling of the ocean by sea-going physical oceanographers.

RELATED PROJECTS

This effort is part of a 5-year (FY04-08) multi-institutional National Ocean Partnership Program (NOPP) project which includes the Florida State University (E. Chassignet, A. Srinivasan), U. of Miami (G. Halliwell, M. Iskandarani, T. Chin, A. Mariano, Z. Garraffo), NRL/STENNIS (H. Hurlburt, A. Wallcraft, J. Metzger, B. Kara, J. Cummings, G. Jacobs, H. Ngodock, C.A. Blain, P. Hogan, J. Kindle), NAVOCEANO (F. Bub), FNMOC (M. Clancy), NRL/MONTEREY (R. Hodur, J. Pullen, P. May), NOAA/NCEP/MMAB (D.B. Rao, C. Lozano), NOAA/NOS (F. Aikman), NOAA/AOML (C. Thacker), NOAA/PMEL (S. Hankin), Planning System Inc. (O.M. Smedstad), NASA-GISS (R. Bleck), SHOM (R. Baraille), LEGI (P. Brasseur), OPeNDAP (P. Cornillon), U. of S. Mississippi (W. Schmitz), U. of N. Carolina (C. Werner), Rutgers (J. Wilkin, D. Haidvogel), U. of S. Florida (R. Weisberg), Fugro-GEOS/Ocean Numerics (D. Szabo, R. Stephens), Horizon Marine Inc. (J. Feeney, S. Anderson), ROFFS (M. Roffer), Orbimage (L. Stathoplos), Shell Oil Company (M. Vogel), ExxonMobil (O. Esenkov).